Wherefore, what is claimed is:

1.   A computer-implemented process for outputting whiteboard content, comprising the following process actions:

5   inputting a sequence of image frames of content written on a whiteboard in real-time;

dividing each of said image frames into cells;

for each cell in each image frame,

determining if there is a change in the cell image compared to a

10   correspondingly located cell the immediately preceding image frame in said sequence of image frames;

whenever it is determined that there is a color change, setting a cell age to a prescribed minimum value, and if there is no change increasing cell age by a prescribed increment value;

15   determining if cell age is greater than a specified threshold value;

whenever the cell age is not greater than the threshold value, not processing said cell any further;

if said cell age is greater than the threshold value,

computing the background color of the cell;

20   updating a whiteboard color model;

classifying each cell image as a foreground or whiteboard cell using said whiteboard color model;

whenever a cell image is classified as a foreground cell not processing that cell any further; and

whenever a cell image is classified as a whiteboard cell, outputting the cell image whenever it exhibits strokes not present in the correspondingly located cell in the preceding image frames or is missing strokes found in the preceding image frames in real-time.

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2.   The computer-implemented process of Claim 1 wherein the image frames are input in Bayer format.

3.   The computer-implemented process of Claim 1 further comprising

10   the process action of outputting the image frame cells so that the strokes on the whiteboard are displayed in an enhanced manner using said cell classification.

4.   The computer-implemented process of Claim 3 wherein the process action of outputting the frame cells so that the strokes on the whiteboard

15   are displayed in an enhanced manner comprises the process actions of:

making the whiteboard background color for cells displaying whiteboard background in said sequence of image frames more uniform;

increasing the stroke saturation of the whiteboard content to make the strokes more vivid and legible; and

20   reducing image noise in said sequence of image frames.

5.   The computer-implemented process of Claim 4 wherein the process action of outputting a cell comprises outputting only changed whiteboard cells.

5   6.   The computer-implemented process of Claim 1, wherein said cell classifying process action comprises:

comparing the input image frame cell to a previous image in a corresponding cell location by comparing the difference between the background color of the cell image and the corresponding color of the whiteboard model;

10   if the difference exceeds a given threshold, designating the cell as a foreground cell, and if the difference does not exceed a given threshold designating the cell as a whiteboard cell;

determining if the cell location was a whiteboard cell in a previous output, and if not designating the cell as a new whiteboard cell and outputting its cell

15   image;

if the cell location was not a whiteboard cell in the previous output, determining if the cell image in the same location of the output is the same and if not outputting its cell image.

20   7.   The computer-implemented process of Claim 6 wherein the difference between a background color of the cell image and the corresponding color in the whiteboard color model is determined by determining the Euclidean

distance between the cell image and the corresponding cell location in the whiteboard color model.

8.   The computer-implemented process of Claim 6 further comprising the process action of verifying that said cell classified as a whiteboard cell is a whiteboard cell, comprising the process actions of:

determining whether said whiteboard cell is connected to any foreground cells; and

if said whiteboard cell is determined to be connected to any foreground cells, classifying it as a foreground cell.

9.   The computer-implemented process of Claim 6 further comprising the process action of verifying that said cell classified as a foreground cell is a foreground cell, comprising the process actions of:

determining whether said foreground cell is connected to other foreground cells; and

if a cell is determined to be a foreground cell and not connected to other cells, classifying it as a whiteboard cell.

10.   The computer-implemented process of Claim 1 wherein the process action of updating the whiteboard color model for the whiteboard and stroke cells comprises the process actions of:

dividing the image of the whiteboard into cells;

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sorting the pixels in each cell according to their luminance value; and

assigning the highest luminance value in each cell as the resulting

whiteboard color of that cell.

5   11.   The computer-implemented process of Claim 10 further comprising

the process action of filtering the colors of the cells comprising the following

process actions:

subjecting the resulting cell colors to a least-median-square error

procedure, which fits a global plane over the colors and throws away the cells

10   that are foreground cells;

designating the remaining cells as whiteboard background cells;

using said remaining whiteboard background cells to update the

whiteboard background;

and filling the holes in the whiteboard color model created by throwing out

15   the cells that were foreground cells with known colors from neighboring cells with

whiteboard background colors.

12.   The computer-implemented process of Claim 1 wherein the

process action of updating the whiteboard color model comprises the process

20   actions of:

dividing the image of the whiteboard into cells;

sorting the pixels in each cell according to their luminance value; and

averaging the top 10% values of the luminance values in each cell and assigning this value as the resulting whiteboard color of that cell.

13.   The computer-implemented process of Claim 1 further comprising correlating said audio recordings with said video.

14.   The computer-implemented process of Claim 1 wherein determining if there is a change in said cell image is computed in Bayer color space.

15.   The computer-implemented process of Claim 1 wherein the background color of the cell is computed in Bayer color space.

16.   The computer-implemented process of Claim 1 wherein the whiteboard color model is computed in Bayer color space.

17.   The computer-implemented process of Claim 1 wherein classifying cell images is computed in Bayer color space.

18.   The computer-implemented process of Claim 1 wherein determining if cell images are the same comprises using a normalized cross-correlation technique to compare two cells at a time.

19. The computer-implemented process of Claim 18 wherein the cross-correlation score ranges from -1, for two images not similar at all, to 1, for two identical images.

20. The computer-implemented process of Claim 19 further comprising a process action of applying a Mahalanobis distance test to determine if two cells are the same.

21. The computer-implemented process of Claim 20 wherein the Mahalanobis distance test given by $d = |\bar{I} - \bar{I'}| / (\sigma + \sigma')$; where I is the first cell image and I' is the second cell image, $\bar{I}$ is the mean color of the first cell image, $\bar{I'}$ is the mean color of the second cell image, σ is the standard deviation from $\bar{I}$ and σ' is the standard deviation from $\bar{I'}$ and wherein I and I' are the two cell images are considered to be identical if and only if $d < T_d$ and $c > T_c$, and wherein $T_d = 2$ and $T_c = 0.707$.

22. The computer-implemented process of Claim 1 wherein the whiteboard color model is dynamically updated by incorporating the background color from the current frame into the existing whiteboard color model.

23. The computer-implemented process of Claim 22 wherein the background color from the whiteboard color model is updated using a Kalman filter technique.

24.   The computer-implemented process of Claim 1 further comprising
the process action of analyzing the sequence of images to isolate key frames
summarizing key points of said whiteboard content.

5   25.   A system for transferring the content of data written on a
whiteboard to at least one remote meeting participant, comprising:

a capture system that captures a sequence of images of content written
on a whiteboard and audio signals corresponding to sounds that occur during a
meeting;

10   an analysis server for analyzing the sequence of images and transmitting
whiteboard content without foreground obstructions and associated audio to a
remote meeting participant in real-time wherein the analysis server comprises
modules for:

dividing each of said images into cells of cell images;

15   for each image,

determining if the cell images have changed from the last frame;

computing the background color of the cell images which represent
the color of blank whiteboard;

updating a whiteboard background model by integrating the color of

20   the blank whiteboard computed from the cell images;

classifying the cell images into foreground or whiteboard cells using
the whiteboard color model;

extracting changed whiteboard content; and

outputting changed whiteboard content to at least one remote
participant.

26. The system of Claim 27 further comprising a module for enhancing
the color of whiteboard content.

27. The system of Claim 25 wherein each image frame is processed in
Bayer color format.

28. The system of Claim 27 wherein the sequence of images are
captured in Bayer color format.

29. The system of Claim 25 wherein the analysis server processes and
outputs changed whiteboard content in real-time.

30. A computer-readable medium having computer-executable
instructions for transferring whiteboard content captured during a meeting in real-
time, said computer executable instructions comprising program modules for:

capturing a sequence of images of content written on a non-electronic
whiteboard in Bayer color format;

recording audio signals correlated with the sequence of images; and

analyzing the sequence of images to transmit said images of the whiteboard and audio signals to at least one remote meeting participant by:

dividing each of said image frames into cells of cell images;

determining if there is a change in the cell image compared to a

5   correspondingly located cell the immediately preceding image frame in said sequence of image frames;

whenever it is determined that there is a color change, setting a cell age to a prescribed minimum value, and if there is no change increasing cell age by a prescribed increment value;

10   determining if cell age is greater than a specified threshold value;

whenever the cell age is not greater than the threshold value, not processing said cell any further;

if said cell age is greater than the threshold value,

computing the background color of the cell;

15   updating a whiteboard color model;

classifying each cell image as a foreground or whiteboard cell using said whiteboard color model;

whenever a cell image is classified as a foreground cell not processing that cell any further; and

20   whenever a cell image is classified as a whiteboard cell, outputting the cell image whenever it exhibits strokes not present in the correspondingly located cell in the preceding image frames or is missing strokes found in the preceding image frames in real-time.

31.   The computer-readable medium of Claim 30 further comprising a
module for correcting for exposure if more than a prescribed percentage of the
cells have changed.

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32.   The computer-readable medium of Claim 31 wherein the
prescribed percentage of cells is 90 percent.

33.   The computer-readable medium of Claim 31 wherein the module

10   for correcting for exposure automatically sets the appropriate amount of light to
be captured to form each image frame in order to avoid over or underexposing
resulting image frame.

34.   The computer-readable medium of Claim 31 wherein the module

15   for correcting for exposure comprises sub-modules for:

initializing the lower and upper limits of a search range of a search
algorithm to be the entire range of the exposure setting;

setting the search range to the average of the lower and upper limits;

measuring over-exposure and under-exposure for each incoming image

20   frame;

exiting the module for correcting exposure if a given incoming image
frame is neither over-exposed or under-exposed;

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if an incoming image frame is over exposed, setting the upper searching limit to the current exposure setting;

if an incoming image frame is under exposed, setting the lower searching limit to the current exposure setting; and

if an incoming image frame is either over exposed or under exposed, setting the exposure of the incoming image frame to the average of the updated lower and upper limits.

35.   A computer-implemented process for creating an enhanced data stream content written on a piece of paper, comprising the following process actions:

inputting a sequence of image frames of content written on the document in real-time;

dividing each of said image frames into cells of cell images;

for each cell location in each image frame,

determining if there is a change in said cell image from the cell in the same location in the previous image frame in said sequence of image frames;

if there is a change, setting cell age to a minimum value, and if there is no changes increasing cell age by a prescribed value;

determining if cell age is greater than a specified value;

if cell age is not greater than a specified value, not processing said cell further for said image frame;

if said cell age is greater than a specified value, computing the background color of the cell;

updating a document color model;

classifying cell images into foreground or document cells using said

5   document color model;

if a cell image is classified as a foreground cell not processing that cell any further for that input image frame; and

if a cell image is not classified as a foreground cell, outputting any cell image frames with newly appeared strokes or newly deleted strokes in real-

10   time.